**Lesson Plan**
**Electric Car**

**Lesson Objectives (Specific, Measurable, Attainable, Realistic, and Timely):**

- Will a lighter electric car perform better (move down a track faster) than a heavier design?
- Is lighter better when designing an electric car?
- How does Newton's 2nd Law of Motion F=Ma affect the design of an electric ear?

**Common Core State Standards to be addressed in this lesson (see attachment):**

**Reading Anchor:** **Writing Anchor:** **Math Anchor:**

**Background Knowledge necessary for students before engaging in this lesson:**

Basic knowledge of the need for transportation to move people and goods
Basic idea of the need for alternative fuels, i.e. less emissions and cleaner air
Basic understanding of Newton's 2nd Law of Motion; F=Ma

**Essential Questions and Lesson Essential Questions for this lesson:** They are open-ended, thought provoking questions that ask students to uncover ideas, problems, controversies, philosophical positions and/or adopt varying perspectives.

- Will a lighter electric car perform better (move down a track faster) than a heavier design?
- Is lighter better when designing an electric car?
- How does Newton's 2nd Law of Motion F=Ma affect the design of an electric car?

**Instructional Planning, Summary of Tasks and Actions:**

Complete sequence of teacher processes and student activities

1. **Anticipatory Set:** Combined with the Introduction below, One class period max
   Photos and short videos, using overhead projector, of:
   - Current electric and plug-in hybrid cars for sale: i.e. Tesla, Toyota Prime, Chevy Volt, etc,
   - Current electric racing vehicles: i.e. Formula E, Land Speed Racer, Drag Car, Motorcycles

2. **Introduction:** Combined with the Anticipatory Set above, One class period max
   PowerPoint / Lecture / Demonstrations:
   - History of the electric car
   - Electric vehicles used for moving goods; Trains, Trucks, cars, etc.
   - Electric vehicles used for moving people; Trains, Trucks, cars, etc.
   - Directed discussion about what the constraints are of using electricity to move people and goods. Direct the focus of the discussion to the conclusion that the efficiency of an electric car is directly related to is weight. Newton's 2nd Law of Motion, F=Ma, where the Force (F) acting on the object is equal to the Mass (M) of the object multiplied by acceleration (a). The underlying idea here is if the force applied stays the same, then to increase performance (acceleration) the mass needs to be less.

   As a class, let's all design and build electric cars and see which car can travel a defined distance the fastest, Electric Car drag race.

3. **Teacher Input:** One class period minimum
   Electric Car Rules – Rules for the Electric Car build and competition will be the:

   ***Department of Energy –***
   ***National Science Bowl Middle School Electric Car Competition Rules***

A copy of the NSB rules will be presented to each student to read, understand and use as a guideline for design. The rules outline what materials, motor, and battery that can be used. However, before copies of the rules are given to students, rules should be revised by the instructor to fit the limitations of their individual facilities. For example, the length of the track might need to be revised to fit the facility or a substitution for a part because of cost. Basically the NSB should be used as a "guide line" for the instructor and class completing this activity. The instructor should keep in mind the NSB rules so students could compete nationally if the opportunity presents itself.

Using the NSB website (http://science.energy.gov/wdts/nsb/competition/middle-school-electric-car/), show short, show short videos of previous competitions so students have a vision of how their cars will be tested. Electric cars can be created from a kit or from a supply of parts ordered by the instructor. A sample of parts to be used should be on display or made available for students to see and touch. This will help build connections to their final design. To prevent students from building the teacher's design and to promote unique designs, do not provide a completed example of a unique design. One simple completed example is appropriate, however the instructor should strongly encourage a "unique" design.

Awards will be given for the race as well as the design. Special awards will be given by celebrity judges, for example; Principal's Pick, Plant Superintendent's Choice, Instructor's Award of Excellence, or Student Store Supervisor's Selection. Students should know that the design and quality of construction will be as important as performance at the track and should not be neglected in this process. The value of the Award should be announced at this time to build in motivation. Due dates will be set at this time by the instructor.

General Question and Answer session should involve each student at this time, the very beginning of this activity. Each subsequent day or meeting should involve free Q&A time as a class to prevent the idea of instructor favoritism. However, students should not have to share a proprietary idea if they feel they have discovered an "edge" or unique solution to the problem.

Safety Guidelines:

Cars will be built at school not at home, therefore all lab safety tests must be completed and current before any lab activities begin. Safety is a learned behavior and a major component in any Project Based Learning activity. Safe use of tools, machines and procedures provide excellent "teachable moments" and should always be a part of the lesson.

4. **Guided Practice:** Two class periods (possibly more)

Design – Once rules and constraints have been presented, students should start their design. Sketches could be completed at home. Allow some time in class for guided instruction by the teacher. Design sketches should be completed and submitted for review by the teacher before actual construction begins. This allows the instructor to gauge and plan for the difficulty of each student car design. When possible, designs should take advantage of available equipment at each facility. For example if a 3D printer is available part of the design should include a part made by that machine. Students should be strongly encouraged to stick to their design and not just build what they see someone else building. The finished product should look like their design sketches, drawings or prints.

CAD Instruction – If CAD software is available it should be incorporated into the design. If CAD is used for designs allow more class time to teach skills necessary for students to complete and print their design.

Note – The difficulty of design should be established by the instructor to fit the abilities of students, capabilities of the facility and guarantee successful completion of car projects.

5. **Independent Practice:**

Car Building – Car building should fit the ability of the students and the resources of the facility. Safety will be a priority. An on \ off switch could be constructed by the students. Hand tools, power tools, machines, soldering of electrical wires and other techniques can be used at the discretion of the instructor. Decisions need to be made about battery handling, storage and if applicable charging. A designated "Testing Facility" should be roped off to provide an area for safe testing. Students should be encouraged make sure the car rolls straight.

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6. **Closure and/or Culmination:** One class period

Car Show – Invite all participating judges to stop by the "Car Show" before Race Day to judge cars. This could be held as an open house in the classroom, cars could be placed in the library, staff lounge or front office. Digital photos could be taken and then ask each teacher to pick from the slideshow their choice.

Race Day – Chose a day and location to race. The Race could be done during lunch or recess to generate student interest. Before the event students, the instructor and staff could make predictions about which car might perform best.

Awards Banquet – Gather students after the event to present Awards. Guest speakers and judges could be invited for the Awards Banquet after the race.

**Formative Assessment(s):** Indicate how students will be assessed and how these assessments will be used to improve instruction

Complete math calculations that answer the Essential Questions of this lesson.

Write answers to Essential Questions, and formulate conclusions about these answers. Try to explain the why or why not for your answers.

Require students to write in reflection about this project writing prompts might include:

Write a reflective Essay about the project. What went well? What went wrong?

Write an instruction manual to build your electric car. Include enough detail that someone who has never seen your car complete could assemble it.

Write a short story about this project.

Write a poem about this project.

Interview a fellow student that competed in the event. Wright an investigative news report about the event that tells the story about the: who, what, why and where.

**Materials, Equipment, Technology and Resources to be used in this lesson:**

Kits that can be used: These are solar cars that can be resourced for this project. Solar cells are included in these kits. The solar cell should be replaced with a battery holder and batteries used as a power source.

SunZoon Lite Kit Solar Car Kit – Pitsco Education

| | | |
|---|---|---|
| Single car kit | part # MG28576 | $11.95 |
| 10-Pack | part # MG35627 | $110.00 |
| 30-Pack | part # MG35626 | $239.00 |

SunEzoon Lite Solar Car Kit – Pitsco Education

| | | |
|---|---|---|
| Single Car Kit | part # MG28574 | $14.95 |
| 10-Pack | part # MG35625 | $125.00 |
| 30-Pack | part # MG35624 | $360.00 |

Battery holders range from $1.20 - $2.99 depending on type (size) and number of batteries used. Availability and cost of batteries should be considered before purchasing battery holders. The recommended battery holder is: *Pitsco - 2 "AA" Battery Holder with cover and switch part # MG32969 $1.50 each, adding $10.50 to the 10-pack price and $45.00 to the 30-pack price.*

The table below lists all of the parts needed to complete this activity. This table is for a class of 30 students building 15 cars working in groups of 2 students. By using resourced parts, students can re-engineer or redesign cars inexpensively to finalize a successful and competitive project. After the Electric Car Project is done the instructor can require students to replace the Battery Holder with the Solar Panel supplied with the kit. The car is now a Solar Vehicle.

| **Part Name** | **Part Description** | **Part Vendor Catalog Part Number** | **Cost (Each)** | **Cost (Class set for 30, groups of 2, 15 cars)** |
|---|---|---|---|---|
| Chassis | Paint Stir Stick | Local Hardware Store | 0 | 0 |
| Electric Motor | Motor 280 | Pitsco MG54428 | 1.75 each | 24.00 (1.60 each) |
| Axles | Steel - 2 ½" long | Pitsco MG53341 | 5.85 (pkg of 100) | 5.85 |
| Front Wheels | GT-FX Wheels | Pitsco MG36685 | 11.00 (pkg of 100) | 11.00 |
| Rear Wheels | GT-RX Wheels | Pitsco MG36687 | 11.00 (pkg of 100) | 11.00 |
| Straws | Plastic Straws | Pitsco MG33890 | 11.95 (pkg of 500) | 11.95 |
| Gears (Motor) | Package M20 | Pitsco 29647 | 12.00 (pkg of 20) | 36.00 |
| Gears (Axle) | Package A3040 | Pitsco 29652 | 12.00 (pkg of 20) | 36.00 |
| Battery Holder | 2 "AA" Battery Holder with cover and switch | Pitsco MG32969 | 1.50 each | 22.50 |
| Alligator Clips | Alligator Clips (Mini Clips) | Pitsco 54665 | 7.30 (pkg of 10) | 21.90 |
| Batteries | 2 "AA" Battery Pack | Pitsco MG51046 | 1.95 (pkg of 2) | 29.25 |
| | | | **Total Cost** | **209.45** |

Other solar car kits that can be substituted and or resourced for this project are:

| | | |
|---|---|---|
| Pitsco Solar Designer Car Kit | part #MG50073 | $11.95 |
| Pitsco Ray Catcher Sprint Deluxe Solar Kit | part # MG21211 | $49.95 |

***National Science Bowl Middle School Electric Car Competition Rules – Car Kit*** (To be resourced by the instructor)

E-flite 3.7V 150mAh, 25c Lithium Polymer Battery
Mabuchi 280 motor
Battery Connector: model PKZ3052
2 LED lights
Balsa wood from the teacher kit must be used for the chassis
On/Off Switch can be used from the teacher kit

Other equipment to consider:
CAD Drafting (computer) Lab
3D Printer
Wood Shop
Hand tools, Power tools, machines for forming wood, sanders, soldering iron,

**References:**

To be compiled and completed at a later date:

Pitsco Advanced Solar vehicle part #36904
http://www.pitsco.com/Homeschool_Advanced_Solar_Vehicles_Pack?SKU=W36904&tp=1
Pitsco Sunzoon Lite Kit part # 28576
http://www.pitsco.com/SunZoon_Lite_Solar_Car?SKU=W28576&tp=1
Pitsco Sunzoon Designer's Kit part # 50073
http://www.pitsco.com/Solar_Designer_Car?SKU=W50073&tp=1
Pitsco Sunzoon Car Kit part 3 28574
http://www.pitsco.com/SunEzoon_Solar_Car?SKU=W28574&tp=1
Pitsco Ray Catcher Kit part # 21211
http://www.pitsco.com/Ray_Catcher_Sprint_Deluxe_Solar_Vehicle?SKU=W21211&tp=1
National Renewable Energy Laboratory – Junior Solar Sprint Kit
http://www.nrel.gov/education/kits.html

Rules:

*Department of Energy – National Science Bowl Middle School Electric Car Competition Rules*

http://science.energy.gov/~/media/wdts/nsb/pdf/Car%20Competition/Car-Rules-2014-National-Science-Bow-Final.docx

*Middle School Electric Car Competition Rules*

http://www.nrel.gov/education/pdfs/electric_car_rules.pdf

Resources:

U.S. Department of Energy National Science Bowl
http://science.energy.gov/wdts/nsb/middle-school/

National Renewable Energy Laboratory
http://www.nrel.gov/news/features/feature_detail.cfm/feature_id=18507